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At Nertschinsk and the other stations of Eastern Siberia the cold is rather strong, but, according to Professor Schwarz, who has spent ten years in those parts, that cold is commonly accompanied with a complete calm and dry air, and thereby it is not unpleasant for astronomical observations. With this conviction, Prof. Schwarz has selected for himself the station of greatest cold, Nertschinsk.

For nearly all the stations the observers are already designed, and will practise themselves this summer at Pulkowa in the use of their instruments. All the telescopes will have an equatoreal mounting; those designed as refractors are provided with clockwork and micrometrical apparatus for measuring the cusps, or the distances from the Sun's limb. Personal equations will be determined by help of an artificial transit apparatus.

The telegraphic longitude determinations through Siberia will be executed in the course of the next two years. The stations selected for that purpose comprehend several *Venus* stations, namely, Nertschinsk, Blagoweschtschensk, Habarowka, Wladiwostok, and Taschkent. The other stations can be easily joined with these by chronometric operations. For the stations near the Caspian and Black Seas, the longitudes are already known with sufficient accuracy. All the observers will be provided with instruments for the determination of time and latitude.

Pulkowa, 1873, *April* 6.

Reply to the Remarks of Mr. Proctor upon the Position of the Lunar Atmosphere, when in a state of Equilibrium. By John J. Plummer, Esq.

(*Communicated by the Rev. Professor Farrar, D.D.*)

In discussing the possibility of our atmosphere enveloping that portion of the lunar surface remote from the Earth, which, being brought to the limb by libration, is the cause of the projection of stars within the lunar periphery, I had taken as a basis the investigations of M. Hansen, published in the *Memoirs of the Royal Astronomical Society*, vol. xxiv. If the correctness of those deductions be denied, my theory at once falls to the ground with them, but if, on the contrary, it be admitted, I can by no means concur in Mr. Proctor's argument. In the first place, I fail to find in M. Hansen's memoir any allusion to the irregular figure mentioned by Mr. Proctor, as representing that of the Moon on Hansen's supposition, nor am I clear upon what principles the centre of symmetry of such a mass would be found. It is true that M. Hansen considers it unlikely that the Moon is exactly spherical, yet he is careful to add, that it is quite possible

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to imagine the laws of its density, by which the same results may be brought about, though the figure be that of a perfect sphere. He prefers to regard our satellite as an ellipsoid with three different axes, and by doing so appears to me to take the only philosophical view of the question possible. We may evidently regard the lunar atmosphere as forming a series of hollow spheres of gradually diminishing density, all having a common centre (viz. the centre of gravity of the entire mass), and broken only where solid matter protrudes through them. The sole question at issue would therefore appear to be, What is the true form of the Moon? for accepting Hansen's theory the centre of gravity is known. Now I conceive that it must be either a sphere or an ellipsoid differing but little from a sphere, because we are unacquainted with any natural laws which could tend to produce an irregular meniscus figure, and I contend that this supposition is not at all at variance with Hansen.

Now, whichever of these regular figures it may be, provided that, if the latter, the ellipticity is not considerable, the fact of the centre of gravity being as much as 36·66 miles further removed from us than the centre of figure, will cause the greatest depth of atmosphere to lie upon the centre of the invisible hemisphere, while the visible disk at mean libration, even to the margin or limb, will be entirely denuded, if the total amount is limited. This is the conclusion arrived at by M. Hansen himself, and clearly shows that he also regards the deviation from the spherical form as being but slight. It may be remarked that this assumption is the more probable, since Newton has calculated that the effect of the Earth's gravity upon a fluid Moon would only elongate the axis in the direction of the radius vector by the insignificant amount of 186 feet, and it does not appear possible to imagine any other cause capable of producing any elongation whatever. It is a curious fact, and one that has not been previously noted, that though there are several methods by which the existence or non-existence of a lunar atmosphere can be demonstrated, not one of them has invariably given negative results.*

Although I am not interested in refuting Mr. Proctor's remarks upon the variation of the Earth's atmosphere, I must

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* In case any one may desire to look for evidence of the lunar atmosphere during the forthcoming partial solar eclipse I have calculated that the geocentric libration of the Moon's disk will amount to exactly 5° at the mean time of conjunction of the Sun and Moon, and that the point of the lunar disk where it attains this maximum amount, is situated at 105° from the north point, measured towards the west for direct image. Towards the latter part of the eclipse it is therefore possible that a bright line of light may be traced upon the solar disk near the western cusp, but the amount of the libration is not favourable to this being very distinctly marked. It is further necessary to remember that at no time during the eclipse does the point of maximum libration actually come within the solar margin, although at Durham and at places still further north it approaches it very nearly, at about half an hour previous to the final contact.

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equally disagree from him on this point also. If we disregard the Earth's rotation, the waters of the ocean will only arrive at the position of equilibrium when every point on their surface is equidistant from the centre of gravity of the Earth, which may or may not be centrically situated with respect to the general surface of the solid portion of the globe. If, therefore, any part is to be regarded as a meniscus, it would seem to be rather the high plateaux and mountain-chains of the northern hemisphere. But in determining the shallowness or depth of the atmosphere reference is always made to the sea-level, or, since the atmosphere is a hollow globe, concentric with the sphere of the ocean, its depth must be everywhere the same measured from that level. Of course the diurnal rotation modifies the fact, though it does not render the argument in any degree inapplicable.

The Observatory, Durham,
May 5th, 1873.

Note on Mr. Plummer's Reply. By Richard A. Proctor, B.A., Cambridge.

In commenting on a point touched upon in Mr. Plummer's former interesting paper, it was not my purpose to attack his theory. I have had no opportunity of forming a theory respecting the projection of stars within the limb. As I understand that experienced observers have recognised the phenomenon (though very seldom), I conclude it is not merely subjective. The fact that observers (also of great experience) have never recognised it, seems to point to another theory than Mr. Plummer's, since one can hardly imagine that these astronomers have not often observed occultations occurring near points of the limb most affected by libration acting towards the Earth. A sufficient explanation seems found in the possible existence of deep clefts: and it appears to me that whereas a star seen through a lunar ravine too narrow to be telescopically discerned in any other way, *would* seem to be projected within the limb, a star affected by refraction would *not* so appear, but would be raised *to* the limb by refraction, gradually fading from view, but throughout appearing on the limb. I must confess that this view of the matter would not explain the systematic occurrence of projection near points of maximum libration; and it would be a point of great interest to observe as many occultations as possible near such points, so as to have a greater number of instances on which to base an opinion. I imagine it would not be found difficult to supply a list of cases of projection occurring at times of mean libration, or even at points of maximum libration *from* the Earth. Some observations which I remember to have read about appear to me

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to force upon us the conclusion that the phenomenon either depends on peculiarities of our own atmosphere, or on lunar irregularities. I would, for instance, cite the following passage from Smyth's *Celestial Cycle*,—

"One of the most remarkable projections of a star on the Moon's disk which I ever observed, was that recorded in the fifth volume of the Astronomical Society's *Memoirs*, p. 363, of 119 *Tauri*, on the 18th December, 1831. On that occasion the night was beautiful, the Moon nearly full, and the telescope adjusted to the star, which passed over the lunar disk" (meaning, I suppose, along the upper limb), "and did not disappear till it arrived between two protuberances on the Moon's bright edge. This was also noted by Mr. Snow, p. 373, of the same volume; but Sir James South saw nothing remarkable, although in a few minutes afterwards he observed the star 120 *Tauri* perform a similar feat." "Such anomalies," adds Smyth, "are truly singular." I cannot but think, however, that they are to be expected as a natural consequence of the unevenness which certainly characterises certain parts of the lunar limb. Many irregularities on the limb must be so minute as to be concealed through the effects of irradiation; and a very slight difference in the position of two observers would suffice to render the observed phenomena at their two stations altogether different.

But I am not concerned to discuss this point at length, having no theory of my own upon the matter, and only an opinion (which may be erroneous) respecting Mr. Plummer's theory.

Turning, however, to the point on which I touched in my former note, I have to remark that my comments related to a more recent phase of the discussion about Hansen's views than that referred to by Mr. Plummer. In 1862 M. Gussew, Director of the Imperial Observatory at Wilna, applied to photographs taken by Dr. De La Rue, processes of careful measurement, which led to the following results:—"The outer parts of the visible lunar disk belong to a sphere having a radius of 1082 miles, the central parts to a sphere having a radius of 1063 miles; the centre of the smaller sphere is about 79 miles nearer to us than the centre of the larger; the line joining the centres is inclined at an angle of about 5° to the line from the Earth at the epoch of mean libration; thus the central part of the Moon's disk is about 60 miles nearer to us than it would be if the Moon were a sphere of the dimensions indicated by the disk's outline." According to these results the Moon would be egg-shaped—at least the visible portion would be shaped like the smaller end of an egg (not differing greatly, however, from a sphere in general shape.) The centre of gravity of the Moon, if of such a figure, and of uniform density, would be farther away than the centre of the diameter directed towards the Earth. It was to this view of the subject, on the probability of which I make no

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comment, that my remarks related. The following passage from a letter of Sir John Herschel's, bearing date May 11, 1870, will be interesting to Mr. Plummer. It relates to my objections to the theory of an atmosphere on the unseen part of the Moon :—"I believe your criticism on my theory" (I had not been aware that Sir John Herschel held the theory when I indicated objections to it) "is just. As for the water there can be no hesitation, —all the lunar oceans might readily subside into a basin 40 miles deep, and a hemisphere broad, without a chance of being seen by libration, but with an atmosphere anything like the Earth's, and only one-sixth the coercive power of gravity, some trace might certainly be expected to crop out at the border."

The slow change of density with elevation, owing to the small power of gravity at the Moon's surface, is a point which must be carefully considered in inquiries relating to a lunar atmosphere. It introduces an objection (fatal, I fear) to Mr. Plummer's ingenious theory.

There are some points in Mr. Plummer's reply which appear to me to be open to exception, but which I have not leisure to discuss so fully as I should wish. For instance, Newton's views as to the figure which would be assumed by a fluid moon are quite inconsistent with the hypothesis of a centre of gravity displaced 36½ miles from the centre of figure, as will be manifest to any one who examines Newton's reasoning. Next, the laws of equilibrium for fluids and liquids do not lead to so simple a result, in the case of an ellipsoid with an eccentric C. G., as Mr. Plummer indicates. Again, regarding the Earth (non-rotating) as a spheroid, with a displaced C. G., a fluid would not be in equilibrium when every point of its surface was equidistant from the Earth's centre of gravity. Mr. Plummer also appears to me to use the word *meniscus* with a more restricted significance than is, I think, usual. I may remark, lastly, that apart from all theory, the depth of the atmosphere, measured from the sea-level, is not "everywhere the same," but markedly less in high southern latitudes than in corresponding northern latitudes,—the difference being equivalent to that due to half a mile of elevation above the sea-level.

Note explanatory of a Stereographic Chart of the Transit of Venus in 1874. By R. A. Proctor, B.A., Cambridge.

This chart is intended to illustrate a relation to which Professor Adams called attention at the last meeting of this Society. If we disregard the rotation of the Earth during ingress or egress, and also neglect the curvature of *Venus's* shadow-cone where it crosses the Earth, it is manifest that the points where the shadow touches the Earth first and last at ingress, or at egress, are respectively antipodal, and may be regarded as the